STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

INSOLUBLE RESIDUES OF THE SAUK SEQUENCE (CAMBRIAN AND LOWER ORDOVICIAN) ROCKS OF THE FAIRFIELD BASIN, ILLINOIS: AN AID IN CORRELATION AND IN PETROLEUM EXPLORATION

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ILLINOIS PETROLEUM 106

ILLINOIS STATE GEOLOGICAL SURVEY
1975
URBANA, IL 61801

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AND EDUCATION

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ABSTRACT

The insoluble residues of drill cuttings from four oil-test holes drilled to the Precambrian basement in the Fairfield Basin, the structurally deep part of the Illinois Basin, were analyzed. Correlations within the Sauk Sequence are based on the resulting data supplemented by information acquired from sample studies, geophysical logs, and X-ray diffraction analyses. Stratigraphic cross sections show that mineralogic zones can be correlated through the thick carbonate sections of the sequence.

The study provides data to support the premise that the rocks of the Sauk Sequence in the deep part of the Illinois Basin contain reservoirs and permeability barriers (especially in the form of anhydrite) that could be favorable to petroleum accumulation.

INTRODUCTION

The Fairfield Basin is the deepest part of the Illinois Basin (fig. 1). Its southern limit is defined by the Rough Creek Lineament, and the remainder is outlined by the minus 4,000-foot contour on the Galena (Trenton) structure map of Bristol and Buschbach (1973, plate 1). The Fairfield Basin extends into Indiana, but only the Illinois part is considered in this report.

Our present knowledge of the rocks of the Sauk Sequence in the Fairfield Basin is based largely on data obtained from four deep oil-test holes that reached the Precambrian igneous basement (fig. 1, table 1). The Sauk Sequence comprises rocks that are bounded by two major unconformities—the sub-Cambrian and the sub-St. Peter unconformities. In Illinois the Sauk rocks are included in the Croixan (late Cambrian) and Canadian (early Ordovician) Series.

The upper part of the Sauk Sequence is a thick section of dominantly dolomite strata assigned to the Knox Megagroup (fig. 2). The lower part of the sequence is dominantly sandstone and is assigned to the Potsdam Megagroup. No widespread structural deformation is known to have occurred in Illinois during deposition of the Sauk strata.

The most recent of the previous geologic reports on the Sauk Sequence in the Illinois Basin (Bond et al., 1971) relied upon correlations between the four holes reported on here and other deep tests in the surrounding, shallower parts of that basin. These correlations were difficult to make for several reasons: (1) Similar lithologies, especially within the dolomites of the Knox Megagroup, produce geophysical logs that lack readily identifiable variations in character. (2) Very few cores were taken during the drilling of these four tests; thus drill cuttings are essentially the only source of rock samples available for study. (3) The long distances between the deep tests in the Illinois Basin make many of the correlations questionable.

Contacts between thick sections of rocks of different types, such as the contact between the dolomite of the Knox Megagroup and the underlying Cambrian sandstones or shales, can be reliably traced from hole to hole. Correlations of individual formations and members within these units, however, are often somewhat nebulous. The purpose of the present study was to obtain data on the minor, noncarbonate materials of the Sauk Sequence in order to make more reliable correlations within the sequence on the basis of these data. Within the Knox Megagroup in particular, the formation boundaries are determined on the basis of distinctive impurities such as chert, quartz fragments, or other types of minor constituents in the dolomite.

LABORATORY PROCEDURE

Drill cuttings were obtained from the files of the Illinois State Geological Survey. When cuttings are received by the Survey, they are routinely washed and stored in paper sample bags. Each bag normally represents a 5- or 10-foot drilling interval. The cuttings used in this study were divided into two equal parts by a sample splitter, and half of the sample was returned to the permanent files. The remaining half of the sample was divided into two equal parts, one for use in X-ray diffraction analysis and the other for use in insoluble residue analysis. The insoluble residues were obtained by soaking the drill cuttings in a beaker containing warm hydrochloric acid. Sufficient time was allowed to dissolve all acid-soluble material. Particles of less than about 20 to 25 microns were removed by decanting, and the weight of the coarser residue was determined.

A visual examination of the coarse insoluble residues was made through a binocular microscope with a zoom lens having a magnification range of from 10 to 20 diameters. Descriptions of materials in the insoluble residues are based on these visual examinations.

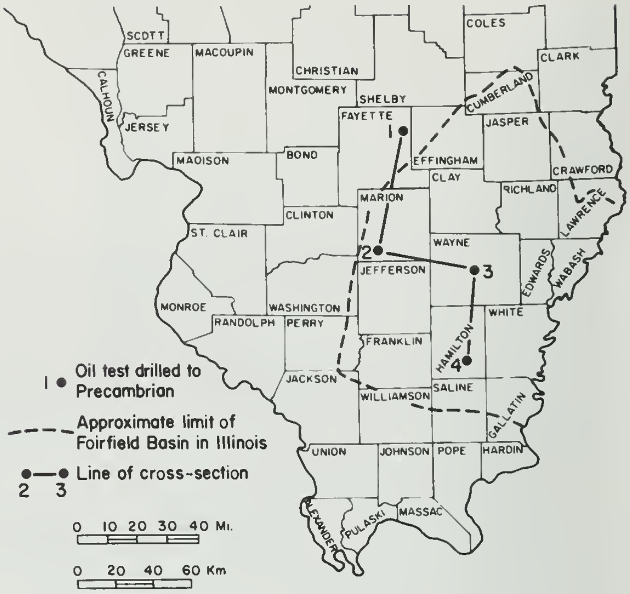

Fig. 1 - Index map showing the boundary of the Fairfield Basin and the locations of holes used in this report.

Description of Insoluble Residues

The insoluble residues encountered in this study were differentiated into nine categories: (1) shale, (2) silt, (3) sand, (4) chert, (5) drusy quartz, (6) feldspar, (7) pyrite, (8) glauconite, and (9) anhydrite. Some of these main categories contain subcategories. Diagnostic features of the materials in each category and subcategory are described below.

Shale

The term "shale" is used in this study to include all predominantly argillaceous material, although some of it contains minor amounts of silt or sand. The dominant color of the shale

TABLE 1 - DEEP OIL-TEST HOLES USED IN THIS STUDY

Text ref. no.	Company	Farm	No.	Sec.	T.	R.	County	Total depth (ft)	Completion date
1	Humble Oil and Refining Co.	Weaber-Horn Unit	1	28	8N	3E	Fayette	8,616	1960
2	Texaco Oil Co.	R. S. Johnson	1	6	1N	2E	Marion	9,210	1966
3	Union Oil Co. of California	Cisne Community	1	3	1S	7E	Wayne	11,614	1967
4	Texaco Oil Co.	E. Cuppy	1	6	6S	7E	Hamilton	13,051	1965

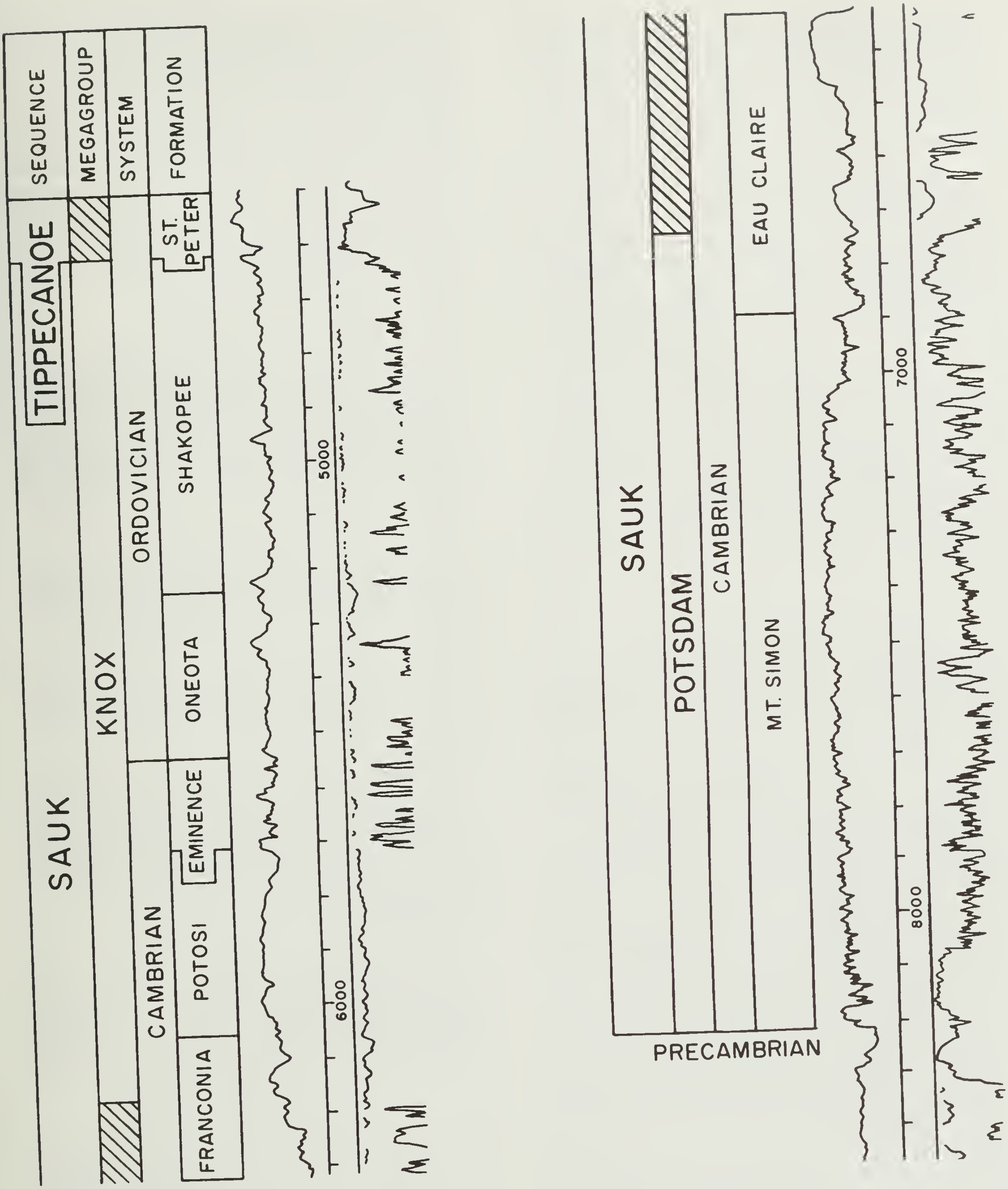

Fig. 2 - Classification and electric log of late Cambrian and early Ordovician strata in hole 1 (Humble No. 1 Weaber-Horn, Sec. 28, T. 8 N., R. 3 E., Fayette County). The Sauk Sequence includes the interval from the base of the St. Peter Sandstone to the base of the Mt. Simon Sandstone.

throughout the Knox ranges from gray to dark gray. Below the Knox, gray to dark gray shales are common, but major amounts of red and green shales also are found. Some shales, particularly the red and green, are micaceous.

Silt

Silt usually occurs as individual silt-sized grains, but a few chips of siltstone are present. Some of the silt grains are composed of chert and some of quartz, but no distinction was made in tabulating the siliceous silt fraction. Minor amounts of sand- or clay-sized material occur in some of the chips of siltstone.

Sand

Sand was found as chips of sandstone and as individual uncemented grains. The sandstone chips are either cemented with silica or pressure-welded. The individual quartz grains may have been cemented with carbonate material, or they may have been scattered throughout carbonate rock. In either case, the carbonate was dissolved by the acid, leaving individual sand grains.

Chert

Several varieties of chert occur. The most common has a vitreous luster and a conchoidal fracture. The color of the vitreous chert is most commonly white to gray although darker colors are present. A few orange-tinted pieces were found.

A less common type of chert found in the residues is microporous and dull rather than vitreous. This type of chert has the appearance of chalk and is referred to in this report as chalky chert to distinguish it from the vitreous variety. The chalky chert rarely displays a pronounced conchoidal fracture.

Sandy chert was recognized in several samples. The quartz sand grains are predominantly well rounded and well to moderately well sorted. They are disseminated throughout the chert matrix in various amounts ranging from sparse scatterings to rather closely spaced clusters. Sand was found in both the vitreous and the chalky chert, but it is more common in the former. A few sand-sized grains of rounded chert, slightly darker than the chert matrix, were observed.

Another variety of chert is described as dolomoldic. This variety of chert was formed by the removal of rhombs of dolomite from a chert matrix by the acid treatment, leaving rhombic holes. These holes are similar in spacing and abundance to the sand grains in the sandy chert. Dolomoldic chert is most commonly vitreous.

The fifth type of chert noted is oolitic. Here again, the matrix is most commonly the vitreous variety of chert. The ooliths commonly have a quartz sand grain as a nucleus. A few quartz grains with no enclosing ooliths can be seen scattered throughout the oolitic chert. Some silicified ooliths are found as loose, uncemented bodies in the residue.

Drusy Quartz

Drusy quartz is found in two forms. The most common form displays well-terminated crystal faces; it apparently formed as linings of open vugs and fractures. The less common variety is anhedral and may represent the complete filling of vugs and fractures, which allowed no crystal faces to form.

Feldspar

A few grains of pink to orange potassium feldspar were observed in the residues. These grains range in size from silt to fine sand.

Pyrite

Small amounts of silt-sized pyrite were found, usually in residues containing dark gray or black shale.

Glauconite

Green, sand-sized pellets of glauconite were found in some zones. These zones are quite restricted with respect to stratigraphic position. Because of this restriction, glauconite is useful in determining the position of some contacts.

Anhydrite

The anhydrite found in the residues was assigned to one of two categories. One includes varieties ranging from massive or formless through finely fibrous to acicular. The other category is clear, tabular anhydrite.

X-ray Diffraction Analysis

X-ray diffraction analysis was performed on the untreated half of the sample to aid in determining the original composition of the cuttings, including the soluble minerals. The procedure involved combining the samples into 50-foot intervals and obtaining a powder diffraction pattern. X-ray diffraction patterns are useful in determining whether calcite or dolomite is the dominant carbonate mineral in the sample. X-ray diffraction analysis is also useful in confirming the identification of anhydrite and feldspar.

CORRELATIONS INDICATED BY INSOLUBLE RESIDUES

A general discussion of the Cambrian and Ordovician stratigraphic classification is contained in a study by Bell et al. (1964). The stratigraphic classification used in our report (fig. 2) is the same as that used by Bell et al., with one minor change—the base of the Knox Megagroup has been shifted upward to exclude the sandy lower portion of the Franconia Formation.

Two stratigraphic cross sections (figs. 3 and 4) are used to illustrate the correlations resulting from the present study. The vertical scale of the logs is shown by depths below surface, as labeled to the left of each log. There is no horizontal scale because the logs were equally spaced for ease of display. The spacing between the four holes is actually nearly equal; it ranges from 30 to 40 miles (fig. 1).

The percentage of total insoluble residue by weight in each 10-foot interval is shown to the right of each log as an open bar graph. The types of materials in the residues that are considered useful in correlation are shown by symbols on the lithologic log with limestone, dolomite, or sandstone patterns.

In figures 3 and 4, formation and member boundaries are projected from log to log as solid lines. The position of the contacts was determined on the basis of insoluble residue data, geophysical log correlations, and studies of drill cuttings. The units within the formations that are connected by dashed lines are informal units recognized by the presence of characteristic suites of insoluble residues.

The following discussion of stratigraphy deals primarily with new data acquired during this study. The regional aspects of each formation are more fully described by Bell et al. (1964).

Mt. Simon Sandstone

The Mt. Simon Sandstone is a fine- to coarse-grained, white to red, partly pebbly sandstone that is friable to well cemented. Beds of red, green, or gray micaceous shale, a few inches to a few feet thick, are common in the upper and lower parts of the formation.

The Mt. Simon Sandstone is present in three of the four holes studied. It is a noncarbonate unit; therefore, any soluble material indicated on the logs is believed to be caved material contained in the bulk samples. Some of the shale indicated may also be cavings. A study of the insoluble residues of this unit is probably of little value because the entire unit is basically quartz.

The Mt. Simon Sandstone is commonly a few hundred to 1,500 feet thick in the Fairfield Basin, but it is locally absent. It thins progressively from holes 1 through 3 and is absent in hole 4. While the thinning appears to be the result of regional differences in the thickness of sand deposited, the complete absence of Mt. Simon in hole 4 is attributed to nondeposition over an isolated Precambrian hill.

Eau Claire Formation

The Eau Claire Formation, which overlies the Mt. Simon Sandstone, consists of a variety of types of rocks in the southern half of Illinois. It is dominantly limestone or dolomite, but it includes siltstone, shale, and sandstone. The formation is 600 to 1,000 feet thick in the Fairfield Basin.

On the basis of insoluble residue content, the Eau Claire can be divided into four units. They are, in ascending order: a lower argillaceous and sandy unit; a lower carbonate unit; an upper argillaceous and sandy unit; and an upper carbonate unit. The varying amounts of total insoluble residues shown by the bar graph (fig. 3) define these four units quite well.

The presence of shale and glauconite in the Eau Claire distinguishes it from the underlying Mt. Simon Sandstone. Also, the percentage of insoluble residue is generally lower in the Eau Claire than in the Mt. Simon. Glauconite is common in the lower part of the formation and is locally present throughout. The top of the Eau Claire in the Illinois Basin is marked by the relatively high shale content of the Eau Claire

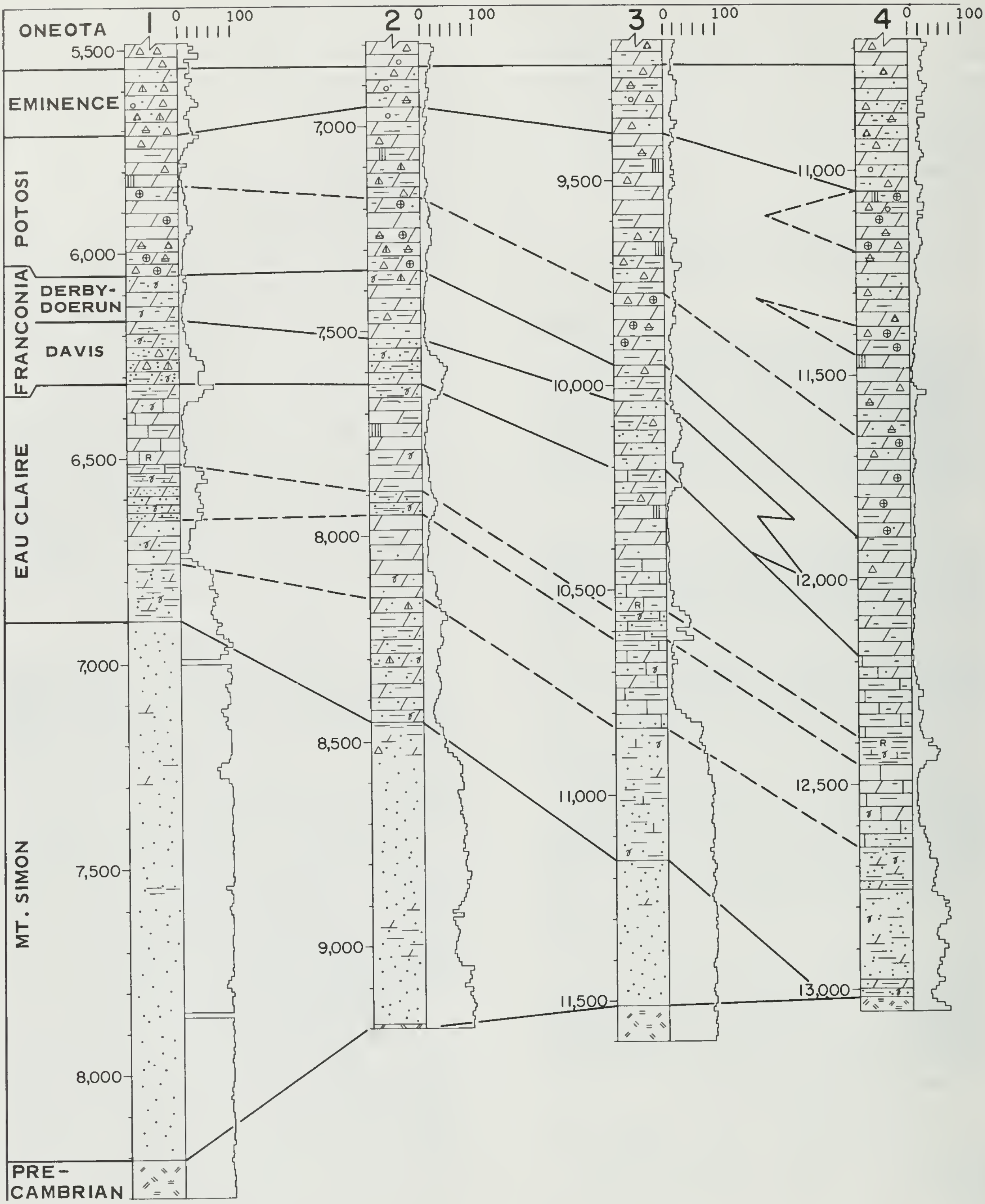

Fig. 3 - Correlation of Croixan (late Cambrian) strata based on insoluble residue data. (Holes used are listed in table 1.) See fig. 4 for legend.

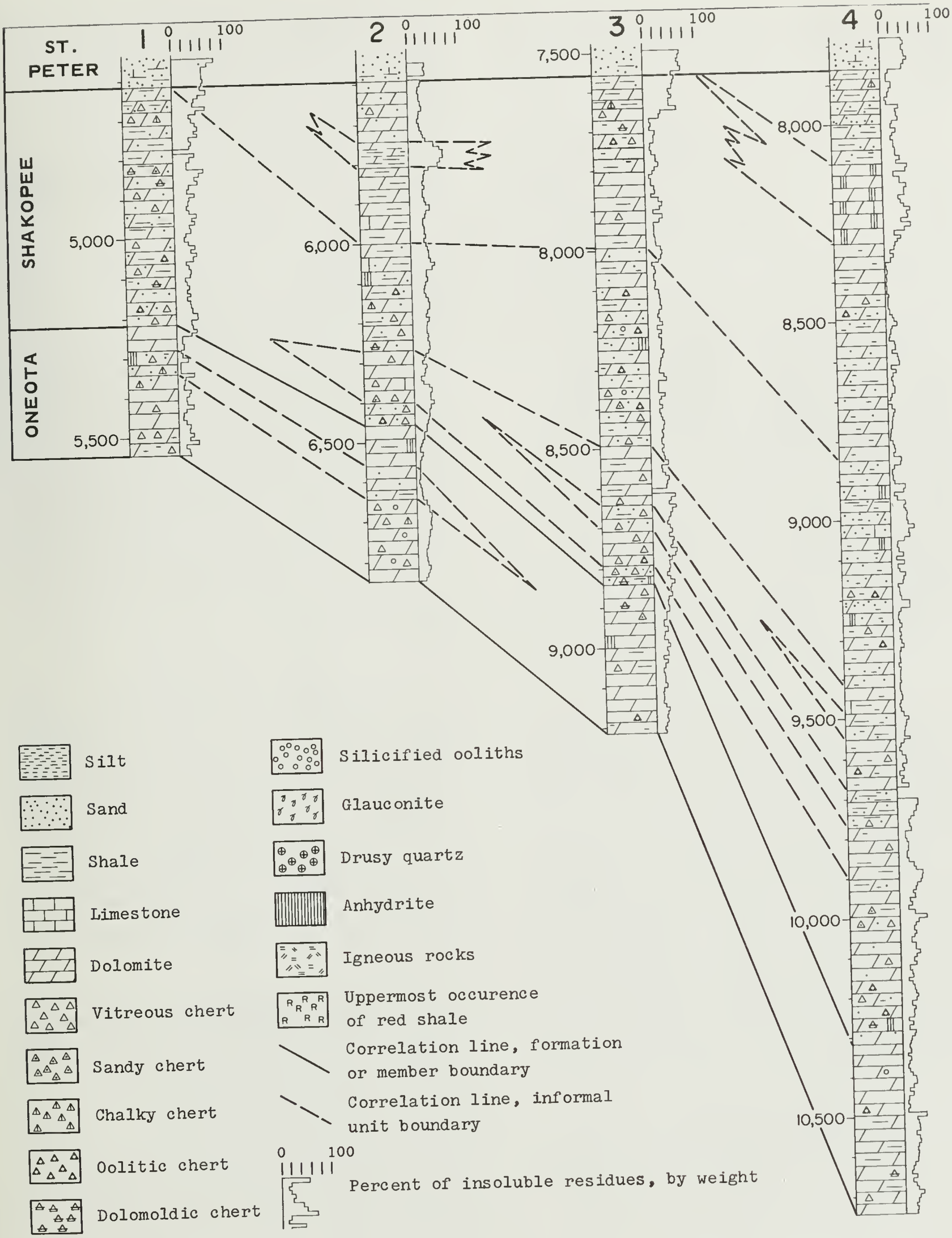

Fig. 4 - Correlation of Canadian (early Ordovician) strata based on insoluble residue data.
(Holes used are listed in table 1.)

or by the downward change from dolomite in the Franconia to limestone in the Eau Claire. Red shale is common in the upper part of the Eau Claire.

Franconia Formation

In most of the Fairfield Basin the Franconia Formation, which overlies the Eau Claire, consists of two members. The lower unit, the Davis Member, is a shaly dolomite which contains a considerable amount of sand, silt, and glauconite. The upper unit, the Derby-Doerun Member, consists of relatively pure dolomite with minor amounts of glauconite, sand, and silt, especially at the top and bottom.

The two members of the Franconia Formation can be recognized in holes 1 through 3. The Davis Member has a high silt and sand content; total insoluble material commonly ranges from 20 to 40 percent. The Davis Member either wedges out to the southeast or, as implied on figure 4, grades laterally into a predominantly dolomite facies.

The most consistent position for the top of the Franconia Formation in all four holes is at the base of the lowest beds that contain abundant drusy quartz. The Franconia is 250 to 300 feet thick in the Fairfield Basin.

Potosi Dolomite

The Potosi Dolomite, which overlies the Franconia, is a relatively pure dolomite that is characterized by the presence of drusy quartz. In most of the Fairfield Basin it is 300 to 600 feet thick, but it appears to be more than 800 feet thick in Hamilton County.

The lower part of the Potosi is characterized by an abundance of drusy quartz in the insoluble residues. Abundant chert fragments of various types also occur in this lower zone. The upper part of the Potosi is slightly to moderately cherty and contains a small amount of sand and tabular anhydrite. The amount of sand increases slightly toward the south and a significant amount of thickening takes place from north to south within this upper zone.

Eminence Dolomite

The Eminence Dolomite is a cherty dolomite, which overlies the Potosi; it contains some sandy beds. It is about 150 to 300 feet thick in the Fairfield Basin.

In insoluble residues the Eminence is distinguished from beds above and below by its sandy character. The Eminence also generally contains more chert than the overlying and underlying rocks. Silicified ooliths were found in the insoluble residues of the Eminence in all four holes. These occur as loose individual ooliths or as small clusters with no chert matrix.

Oneota Dolomite

The Oneota Dolomite, which overlies the Eminence, is a light-colored, medium- to coarse-grained cherty dolomite. It is 300 to 400 feet thick in the Fairfield Basin.

The Oneota is essentially sand free and is distinguished in insoluble residues from the underlying Eminence and overlying Shakopee Dolomites on that basis. A slightly sandy zone occurs within the Oneota in holes 1 and 2. Chert is fairly abundant in all four holes at the positions indicated by chert symbols on the logs (fig. 3). Bell et al. (1964) suggested the presence of the Gunter Sandstone at the base of the Oneota in the Weaber-Horn test (hole 1), but the Gunter was not indicated by the presence of sand in the insoluble residues from any well examined in this study.

Shakopee Dolomite

The Shakopee Dolomite, which overlies the Oneota, is an argillaceous to pure fine-grained dolomite with thin beds of sandstone and green or gray shale. Oolitic chert is common. The Shakopee thickens southeastward across the Fairfield Basin from 600 to about 2,500 feet.

The Shakopee is relatively high in insoluble residue content. Noncarbonate material commonly accounts for 20 to 40 percent of the total sample weight. It is quite sandy except for some zones in the lower part of the formation (fig. 4).

In hole 4 anhydrite of the massive to acicular variety is common throughout much of the Shakopee and is particularly abundant in the upper part of the formation above a unit that contains relatively little sand and chert.

Oolitic chert is present in varying amounts throughout the Knox, but it becomes especially conspicuous in several zones in the lower one-half to two-thirds of the Shakopee. The number of these oolitic chert zones increases to the south as the thickness of the Shakopee increases. The thickening in this cherty portion of the Shakopee together with the thickening of the upper part of the Potosi accounts for a major part of the total thickening in the Knox Megagroup from north to south.

Summary of Insoluble Residues

Generally, no single type of insoluble residue can be used to identify positively any specific formation or member of the Sauk Sequence. Nevertheless, each formation contains a characteristic assemblage of insoluble material that is helpful in correlating the strata of the sequence. The assemblages presented here (table 2) should be useful in future correlations with deep holes drilled in and around the Fairfield Basin.

TABLE 2 - CHARACTERISTIC INSOLUBLE RESIDUES FOUND IN THE SAUK SEQUENCE OF THE FAIRFIELD BASIN

Formation	Subdivision (if any)	Amount of insoluble residue	Type of residue
Shakopee		15% - 40%	Quartz sand and chert dominant in lower part; chert most commonly vitreous; some dolomoldic, sandy, chalky, and oolitic chert; oolitic chert increases to south in lower part; argillaceous, sand-free unit with rare chert is present in upper part of holes 2 and 3; tabular anhydrite present in lowermost part of holes 2, 3, and 4; massive anhydrite present in hole 4.
Oneota		10% - 40%	Chert is dominant, mostly vitreous; some chalky, dolomoldic, and oolitic chert; little silt and shale; some sand in holes 1 and 2; some tabular anhydrite in holes 1, 2, and 3.
Eminence		10% - 40%	Moderately abundant to abundant chert, mostly vitreous; some dolomoldic, chalky, and oolitic chert; free, silicified ooliths; moderate to small amounts of quartz sand.
Potosi		3% - 20%	Drusy quartz common in lower part, rare in upper except in hole 4; variety of chert (dolomoldic, vitreous, oolitic, chalky) common in holes 1 and 2, less so in 3 and 4; clear tabular anhydrite in upper part; little sand, silt, and shale.
Franconia	Derby-Doerun Member	3% - 15%	Quartz sand dominant in holes 1 and 2; silt and shale dominant in holes 3 and 4; glauconite in holes 1 and 2; chert is mostly vitreous; some chalky chert.
	Davis Member	20% - 50%	Quartz sand is dominant; fair amount of silt and shale; glauconite in holes 1 and 2; chert, where present, commonly vitreous; some chalky chert.
Eau Claire	Upper carbonate unit	2% - 20%	Shale dominant; quartz sand; silt and glauconite in holes 1 and 2; a little tabular anhydrite in holes 2 and 3.
	Upper sandy, argillaceous unit	15% - 50%	Quartz sand; glauconite; some red shale.
	Lower carbonate unit	10% - 20%	Quartz sand; glauconite; little red shale.
	Lower sandy, argillaceous unit	25% - 85%	Quartz sand; abundant glauconite; red shale; little silt.
Mt. Simon		Generally 80% - 100%	Quartz sand, generally fine to medium, some coarse, angular to rounded; potassium feldspar.

OIL AND GAS POSSIBILITIES

The most recent discussion of the possibility of oil and gas accumulations in the Sauk Sequence in the Illinois Basin (Bond et al., 1971) cites evidence for the existence of reservoirs, permeability barriers, and petroleum source rocks in this thick sequence of strata. Data obtained from the study of insoluble residues further indicate the presence of the first two of these three features that are essential requirements for the accumulation of oil or gas.

The Sauk Sequence is generally quite dense. This is particularly true of the dolomites of the Knox Megagroup. However, there is some evidence of porous zones within these dolomites. Porosity is indirectly indicated by the presence of drusy quartz throughout various intervals in the dolomite section of the Potosi. Well-terminated quartz crystals require void spaces in which to grow. Their presence in the insoluble residues indicates voids possessing dimensions at least greater than those of the crystals. Quartz of a vein-filling type is also found in varying abundance throughout the Knox Megagroup. This type of quartz probably indicates the presence of a fracture system that has been filled with secondary quartz. Other fracture systems that have not been completely filled also could exist in the dolomites of the Knox. A combination of vugs and interconnecting open fractures would produce a reservoir within the Knox Megagroup. Some cores taken from the Knox show the existence of such vugs and fractures. An example is shown in polished section in figure 5. High porosity would not necessarily be required for commercial production if a thick section were involved and free communication of fluids were made possible by such a system of interconnected fractures and vugs.

The presence of quartz sand grains in relative abundance suggests the possibility that primary porosity exists in many zones in the Knox. While many of these quartz grains undoubtedly occur as isolated grains in a dolomite matrix, some are found in cemented clusters that may be fragments of sandstone beds or lenses. Some intervals contain enough loose sand grains to suggest the existence of relatively friable sandstones within the dolomites. If this is the case, it is possible that sandstone reservoirs of sufficient size to contain commercial quantities of oil or gas may be found in the Knox.

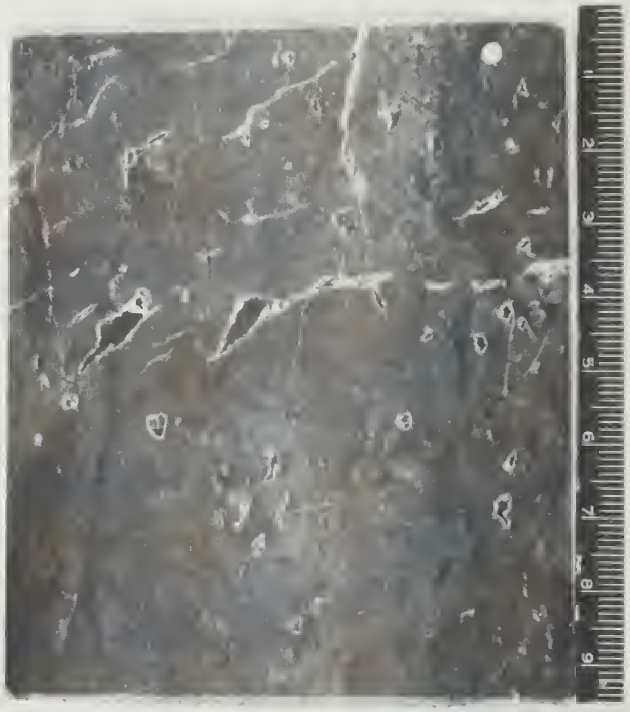

Fig. 5 - Polished core of Shakopee Dolomite (at depth of 9,669 feet) taken from the Texaco No. 1 Cuppy, Hamilton County, Illinois (hole 4 of this report). Porosity can be seen in the form of vugs (black areas) and fractures (white lines). (The straight vertical line in the lower left quadrant of the core is a scratch on the core.) Scale is in centimeters.

These indirect indications of the presence of zones of significant porosity in the Knox, along with the more direct indications provided by geophysical logs, lost circulation of mud during drilling operations, and recovery of fluid on drill-stem tests (Bond et al., 1971, p. 1202), show that reservoirs are present in the dolomites of the Knox Megagroup.

The absence of a permeability barrier above the Knox Megagroup in Illinois has been a perplexing problem for petroleum explorationists. The St. Peter Sandstone covers the Knox dolomites over the entire Illinois part of the Illinois Basin. Although this sandstone varies in thickness and becomes less permeable to the southeast, it certainly is not the type of rock that is considered an effective barrier to fluid migration. Therefore, if oil is trapped within the Knox, the permeability barriers must be within the Knox itself. Dense dolomites might serve as such barriers; but if reservoir capacity in the Knox is a result, even in part, of fracturing, it is likely that the fracturing destroyed the ability of these dolomites to serve as permeability barriers.

However, the presence of anhydrite in the insoluble residue in some of the holes in this study suggests that there may be permeability barriers in the Sauk Sequence. These barriers could be beds of either anhydrite or anhydritic dolomite. The greatest amount of anhydrite seen in this study is present in the deepest of the four holes examined—hole 4. In that hole, the insoluble residue of portions of the Shakopee Dolomite represents up to 40 percent by weight of the total rock. About 40 percent of this insoluble residue in some samples is anhydrite. Anhydrite is also present in hole 3 in Wayne County, but to a lesser degree than in hole 4.

Some core samples of the Knox from White County, Illinois (Superior No. C-17 Ford, sec. 27, T. 4 S., R. 14 W.), contain from 3 to 5 percent anhydrite (Saxby and Lamar, 1957). There is no significant amount of anhydrite in holes 1 and 2. An increase in the amount of anhydrite toward the thicker part of the Knox suggests that evaporites may exist in greater abundance to the south of hole 4. Brehm (1971, fig. 2) points out the possibility that algal dolomite with anhydrite caps may be present in the Knox of southern Illinois. An interfingering relationship of dolomites possessing reservoir properties with dense, impermeable beds of anhydrite would produce favorable conditions for trapping oil or gas.

This study of insoluble residues has not produced any new evidence to support the belief that petroleum source beds exist in the Knox; however, other data indicate that some petroleum-generating potential exists within this thick dolomite sequence. The recovery of free oil during a drill-stem test of the Knox at hole 3 and the presence of significant amounts of organic carbon and benzene-extractable hydrocarbons in Knox dolomite (Bond et al., 1971) indicate that oil source rocks may be present in the Knox of Illinois.

CONCLUSIONS

For some time certain parts of the Sauk Sequence in and around the Illinois Basin, especially the Knox Dolomite Megagroup, have presented geologists with problems of correlation. Geologists working in zinc mines of eastern Tennessee found that key beds of sand, shale, or chert nodules could be traced over long distances in the Knox (Harris, 1973, p. 64). The examination of similar materials in the form of insoluble residues obtained from drill cuttings used in our study indicates that the same lateral persistence of certain mineralogic zones exists in the Knox of the Fairfield Basin. This lateral persistence was useful in making the correlations shown in figures 3 and 4. In some cases a single type of residue was used to recognize boundaries between formations. For example, the sharp lower limit of abundant drusy quartz provides a readily recognizable base of the Potosi. In other zones, where heavy reliance cannot be placed on one distinctive type of residue, characteristic suites of insoluble residues occur in apparently correlative zones. Work with insoluble residues of the Cambrian and Ordovician rocks of some of the states near Illinois suggests that regional correlations based on this kind of study may be possible. Work in Missouri (McCracken, 1952), Indiana (Gutstadt, 1958), and Tennessee (Pierce, 1957) has shown that distinctive sequences of noncarbonate material aid in correlation of Cambrian and Ordovician rocks within those states. With the drilling of more deep tests and with standardization of techniques to be used in future studies, perhaps correlations of higher reliability will be made over wide areas.

The cross sections in this report provide a basinward extension to those shown by Atherton (1971, p. 34). The southernmost hole (A) in Atherton's work is the same as hole 1 of figures 3 and 4 of this report. The more detailed zoning of the Sauk Sequence accomplished by insoluble residue studies should provide an aid in correlating strata in any future deep test holes drilled in the area of the Fairfield Basin with those in holes previously drilled. As these correlations become better understood and more reliable, the evaluation of possibilities for petroleum accumulations in these deeper rocks will be facilitated.

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